FIELD DEMONSTRATION OF THE MULTI-SENSOR TOWED ARRAY DETECTION SYSTEM (*MTADS*)

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ABSTRACT

The Chemistry Division of the Naval Research Laboratory, with support from the Environmental Security Technology Certification Program, has developed a Multi-Sensor Towed Array Detection System (*MTADS*) for characterization of UXO sites for buried ordnance. The system consists of a specially designed tow vehicle and tow platforms that support arrays of total field magnetometers and pulsed-induction sensors. Sensor data is collected by computers aboard the tow vehicle and correlated with cm-level GPS positions. The raw data are mapped and presented to an analyst for interactive target location and classification using a sophisticated Data Analysis System running on a UNIX workstation. Extensive target signature data have been taken for use as training sets and two major field demonstrations have been conducted at the Magnetic Test Range at Twentynine Palms, CA in December, 1996 and at the Jefferson Proving Ground, IN ranges in January, 1997. This discussion focuses on the results of the Twentynine Palms demonstration surveys.

INTRODUCTION

The Naval Research Laboratory, under a program funded by the Environmental Security Technology Certification Program, ESTCP, (Marqusee, 1996) has developed the Multi-sensor Towed Array Detection System, *MTADS*, for ordnance detection and site characterization. A primary goal of this program is to provide field demonstrations of a towed array sensor systems that use state-of-the-art technologies for automated detection of Ordnance and Explosive Waste (OEW). To achieve this goal, we have assembled a field-worthy system consisting of advanced, real-time, centimeter-level GPS location and guidance, a sophisticated data acquisition system, arrays of total field magnetometers and pulsed induction sensors and an advanced Data Analysis System (DAS).

Sensors

The magnetometers used in the *MTADS* array, selected for low heading error and sensor-to-sensor offsets, are designated as Model 822ROV by Geometrics, the manufacturer. When used in the total field magnetometer mode, the eight sensors are arranged in a linear array 1.75 m wide with a horizontal sensor spacing of 0.25 m. The sensors can be set to heights of 0.25, 0.40 or 0.55 m above the surface. Alternatively, the sensors can be arranged in vertically-mounted pairs. In the gradiometer configuration the sensors measure the vertical gradient of the Earth's total field. In this case the horizontal spacing is 0.5 m with a vertical spacing of 0.55 m. This results in a total array width of 1.5 m.

In each case, the sensor arrays are mounted on the *MTADS* passive tow platform which maintains the sensor arrays at a distance of 4.9 m behind the tow vehicle. Total field magnetometer data are obtained by processing the raw magnetometer Larmor frequency using Geometrics G-822A counters, and this information is transmitted to the Data Acquisition Computer (DAQ). In both total field and gradiometer mode, all eight total field readings are recorded. The vertical gradient is computed later by the DAS. Magnetometer data are collected at 50 Hz. Combined with our typical survey rate of 3 m/s, this corresponds to a sampling interval of 6 cm in the direction of travel. This allows us to completely characterize signatures with a spatial wavelength $\geq$ 12 cm.

The pulsed induction sensor array is composed of three Geonics EM-61 sensors highly-modified to make the array compatible with vehicular towing, to increase the sensitivity to small and intermediate sized objects, and to permit their detection at increased depths. To increase the survey data density we increased the transmit pulse repetition frequency, decreased the analog time constant, and increased the digitizer sampling rate. Sensitivity was improved by increasing the amplifier gain and moving the sampling gate closer to the transmit pulse. The 1m square EM-61 sensors are deployed in an overlapping array of three to improve the horizontal resolution. The *MTADS* active tow platform positions the EM array 3.1 m behind the tow vehicle. The EM receiver coil signals are transmitted to the DAQ computer in the tow vehicle. The sample rate for the EM sensors is 10 Hz. We typically survey with these sensors at a speed of 1.5 m/s, which results in a spatial sampling interval of 15 cm. Figure 1 shows the *MTADS* surveying with the active platform using the EM sensor array.

Navigation

Figure 1. *MTADS* Tow Vehicle with Active EM Platform.

The sensor positions are determined using GPS navigation (Trimble Model 7400) employing Real-Time Kinematic, On-The-Fly resolution of integer ambiguities (RTK/OTF) mode. This technology provides 5 cm level accuracy with 5 Hz updates. The GPS satellite clock time is used to time-stamp both position and sensor data for later correlation. In addition, an electronic compass, attitude sensors (pitch, roll and yaw), and tick wheel sensors provide navigation back-up and dead-reckoning capability. All navigation and sensor data are provided through electronic interfaces to the DAQ in the Tow Vehicle. The DAQ computer also functions as a survey set-up tool and provides real-time guidance displays and information for the driver.

Hardware

The Tow Vehicle, shown in Figure 1, is custom-built by Chenowth Racing Vehicles. It is an off-road vehicle specially modified to have an extremely low magnetic self-signature. Most ferrous components have been removed from the body, drive train and engine and replaced by nonferrous alloys to minimize the directional offsets at the sensors. The measured offset at the sensor arrays is <5 nTesla, which is compensated for in software. The Tow Vehicle houses the DAQ computers, which integrate and record all sensor data streams. The computers are also used to lay out survey setups, record landmark files, create survey layouts and present the driver with real-time guidance and survey progress images *via* a touch screen display mounted beside the steering wheel. The DAQ computers also support post survey landmarking and way pointing of targets for remediation.

Data Analysis

Survey data in the DAQ computer is down-loaded by tape or hard wire connection to a notebook computer for transfer to the (DAS) computer. The DAS software was developed specifically for this program as a stand alone suite of programs written using IDL development tools, and graphical user interfaces (GUI's), working in a UNIX-based workstation environment. The DAS is written to be used by both sophisticated and novice users. Even the novice user can perform a complete data analysis using menu-driven tools and the background default analysis settings. An extensive range of expert options are also available to facilitate the cleanup of navigation data, sensor nulling and leveling, noise filtering, and other electronic data preprocessing options.

The DAS uses resident independent, physics-based, algorithms to execute target analyses interactively using magnetometry, gradiometry, and EM data. Extensive training data sets (using inert ordnance) have been taken and used to refine the algorithms to improve target analysis. (Barrow, 1997) In addition to position, depth, and size solutions, magnetic analyses provide target orientation and effective caliber information and, using a "goodness of fit" analysis, provide guidance in distinguishing probable ordnance from non-ordnance targets to reduce the false positive targets.

TRAINING DATA SETS

In support of construction and validation of algorithms for target characterization and location we collected an extensive set of ordnance signatures using the sensor arrays. The ordnance included 20, 30 and 40 mm rounds and submunitions, grenades, rockets, projectiles and general purpose bombs up to the Mk 82. Signatures were measured as a function of depth and orientation. These results have been described (Nelson, *et al.*, 1997) and are available from NRL for approved users and developers.

DEMONSTRATION SITES

Under ESTCP sponsorship the *MTADS* has conducted extensive survey demonstrations at the Magnetic Test Range in Twentynine Palms, CA (December 1996) and on three of the ten-acre sites at the Jefferson Proving Ground (January 1997) following the JPG III demonstrations by commercial vendors during the summer and fall. This presentation emphasizes the results of the surveys at the Magnetic Test Range. However, we also present preliminary results from the JPG surveys.

THE MAGNETIC TEST RANGE

The Marine Corps Air Ground Combat Center (MCAGCC) in Twentynine Palms, CA is the largest live fire training range in the United States. The Magnetic Test Range (MTR) at the MCAGCC was established in the late 1980's to serve as a test and evaluation site for prototype UXO detection systems. The field is located in a desert environment, which is typical of many live-fire ranges located in the western half of the United States. Soils are fairly conductive and have a significant magnetic background. Range deterioration due to environmental degradation has been minimal. Contamination includes surface clutter such as tent stakes, com wire (iron), and discarded food and beverage containers and a significant assortment of other ferrous scrap and clutter. Much of this clutter has been buried by the blowing and drifting sand.

We tested other prototype towed-arrays at the site during the late 1980's and early 1990's. In August of 1992, the site was used to evaluate the performance of two gradiometer systems; the Forster Model 4.021 (military designation MK-26), and the Schonstedt Model GA-72CV. Four marine groups from the MCAGCC Explosive Ordnance Disposal (EOD) Team resident at Twentynine Palms executed data collection for this evaluation. Results of these studies have previously been reported (Naval Explosive Ordnance Disposal Technology Center, 1992).

The MTR encompasses about 8 acres; the schematic layout is as shown in Figure 2. The surface is reasonably level and free of vegetation and other obstructions. There are two shallow arroyos crossing the site near the north and south edges that cannot be crossed at all points by the Tow Vehicle; thus some areas must be filled in by driving along the cuts. Figure 3 shows the *MTADS* traversing one of the other smaller man-made features on the site.

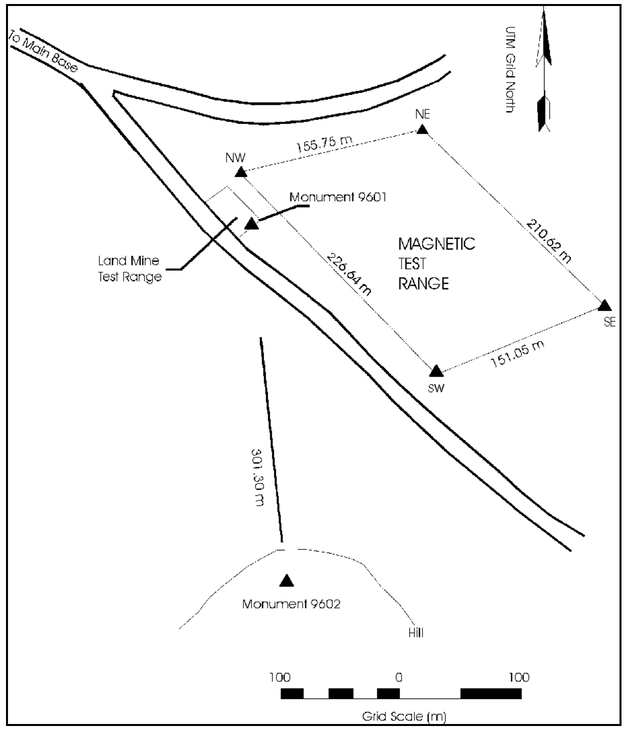

Figure 2. Schematic layout of the Magnetic Test Range (MTR) at Twentynine Palms, CA.

There are 70 ordnance items located within the perimeter of the MTR. Table 1 provides information about the range and types of ordnance. Additionally, before beginning the surveys, we placed 35 twelve inch long

Figure 3. *MTAS* Tow Vehicle and magnetometer array traversing a man-made feature at

pieces of 3/8 inch rebar as registration targets along the north and south perimeters of the site. They were vertically driven flush with the surface and their positions determined precisely by way pointing using the *MTADS* Tow Vehicle.

Table 1. Ordnance Inventory at the MTR

Ordnance	Number of Items	Range of Depths (m)
60 mm Mortar	10	0.15-0.46
81 mm Mortar	7	0.46-0.76
105 mm Projectile	10	0.46-1.10
155 mm Projectile	10	0.61-1.22
8" Projectile	10	1.83-2.74
Mk 81 Bomb	10	1.43-3.11
Mk 82 Bomb	10	1.22-4.42
Mk 117 Bomb	1	3.96
Mk 83 Bomb	1	5.09
Mk 84 Bomb	1	4.88

MTADS SURVEYS

Three complete surveys of the MTR were carried out using the *MTADS* towed arrays. For the magnetometer survey a magnetometer reference station was set up on a neutral site south of the MTR to record the time-varying Earth's field for later correction. For all surveys the navigation base station was set up over the first-order control point that was established at the southern edge of the mine test range.

The magnetometer survey was conducted with the sensors set 25 cm above the surface with a horizontal array spacing of 25 cm. The survey was conducted driving lines parallel to the long site dimensions with small fill-in surveys driven orthogonally along the north and south perimeters. The total time required to complete the magnetometry survey was 175 minutes. Figure 4 shows an interpolated magnetic anomaly image for the entire site.

The sensor array was reconfigured with pairs of sensors vertically mounted 40 and 95 cm above the ground. The horizontal array spacing was adjusted to 0.5 m and a gradiometer survey was conducted. The individual sensor readings were recorded. The vertical signal differences were computed during the DAS processing. With the data recorded in this way gradiometer survey data can also be processed as two separate magnetometer surveys with the sensor positions at 40 or 95 cm above the ground (with a 0.55 m horizontal sensor separation). The survey layout

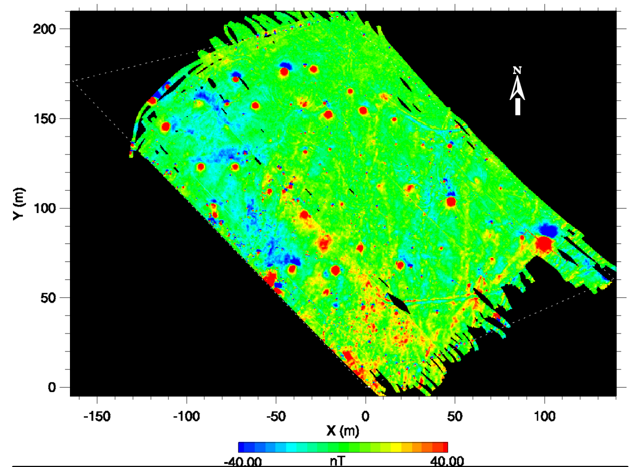

Figure 4. Interpolated magnetic anomaly image of the MTR at Twentynine Palms, CA.

grid was identical to that used for the magnetometry survey. The total time required to complete the gradiometer survey was 185 minutes.

The active sensor platform was used to conduct the EM survey. As explained above, the two outboard sensors are mounted adjacent to each other. As shown in Fig, 1, the third sensor is mounted centered on the outboard sensors, overlapping each by 0.5 m. The transmit pulses from all three sensors are synchronized and each of the six receive coils measures the transient return signal at 10 Hz with an identical sampling window. The survey grid was set up with the lanes parallel to the short dimension of the site, *i.e.* the survey was carried out generally in an east-west direction. The total EM survey time was 305 minutes. Because of intermittent problems with one of the receive coils several small sections of the survey were retaken. This work is included in the survey time cited above.

DATA ANALYSIS

The IDA Data Analysis

Because NRL had access to the baseline truth data, arrangements were made to conduct an independent blind analysis by a third party of the data using the *MTADS* DAS. The Institute for Defense Analyses (IDA) carried out this study. For this purpose the *MTADS* DAS was installed on an SGI workstation at IDA and the DAS manuals were provided, as was some initial instruction in analysis operations. While the *MTADS* DAS procedures were used by IDA to fit individual targets, they devised their own analysis schemes for target classification and evaluation based upon the fitting parameters generated by the DAS, the appearance of individual target graphical images and other intuitive information derived from the target presentations. Each data set was analyzed independently, and no attempt was made to correlate target information among data sets.

The EM data set was evaluated by IDA using a straight forward application of the DAS routines. Suspected targets were identified in the analysis window presentations (after appropriate display scaling), they were boxed using the mouse and the analysis algorithm iteratively fit the target. The analyst either declared the fit as a target, rejected the fit and reboxed the target for another fit, or rejected the image as a target. All declared targets were accepted as ordnance; no attempt was made to differentiate ordnance from non-ordnance.

IDA used a much different approach for analyzing the magnetometry and gradiometer surveys. Based upon experience analyzing data from our ordnance data training sets, complex probability evaluation criteria were developed for use in analyzing targets. Targets are chosen for analysis and fit using the *MTADS* DAS routines. Based upon the fit information, the visual appearance of the target and its immediate geophysical and clutter environment, a probability value between 0 and 6 was assigned to the individual target fit. A 0 value indicates the highest probability that the target is ordnance, an assigned value of 6 represents a target that is most likely not ordnance. Independent analyses were carried out on the magnetometry and gradiometer surveys and no attempt was made to correlate targets between data sets.

NRL Data Analysis

NRL independently carried out target analysis of the magnetometry, gradiometry and EM data sets. The data sets were first analyzed independently, then correlated as described below. The EM data set was analyzed, as described in the IDA analysis discussion. All targets that were chosen for analysis and satisfactorily fit, were declared as ordnance.

The magnetometry and gradiometer data sets were independently analyzed. All anomalies chosen for analysis were declared as ordnance or not-ordnance following the fit. Assignment criteria were based upon the complexity of the target being fit (did it appear as a cluster of smaller items?), the “goodness of fit” parameter, and most strongly, on the computed size of the target. Other factors were also considered. Did the dipole have an impossible orientation (indicating an item with a strong remnant moment)? Did the target have a computed depth of 0 and a very large computed size? Based upon an assumed smallest ordnance size of 60 mm, targets with reasonable fit parameters and a computed size of 30 mm or less were declared as not-ordnance.

Following the three independent survey analyses, targets were correlated between survey data sets. The *MTADS* DAS can simultaneously display in two adjacent analysis windows from separate surveys with the same presentations from each survey. Using this approach the magnetometer and gradiometer surveys were compared target-by-target. In most instances the targets were common between the data sets. In some instances targets appeared in one set, but not the other. Deeper magnetometer targets are sometimes not detectable in gradiometer presentations. On some occasions, reasonable target fits in the magnetometer data set clearly broke up into clustered targets in the gradiometer set; in this case the gradiometer fits took precedence. If gradiometer and magnetometer target fits were similar, the magnetometer values took precedence because of the 0.25 meter sensor separation in the magnetometer survey. This comparison removed a small number of ordnance declarations from the magnetometer survey analysis, but had the overall effect of increasing the total number of ordnance declarations.

As the next step, the magnetometer and EM survey presentations were compared target by target. Because the EM array has a much higher sensitivity for very small, shallow targets than the passive sensors, this detection capability provided a significant discriminant. In the comparison of common targets between the EM and magnetometer sets, magnetometer fits that were too small to be declared as ordnance were excluded from the EM target list. Rather surprisingly, a significant number of shallow declared magnetometer ordnance targets were too weak to be selected in the EM presentations. These magnetometer targets then became suspect as resulting from small objects with high remnant moments or tight clusters of extremely small ferrous objects. Some magnetometer targets with analyzed sizes of 40-50 mm and analyzed depths of <1 meter which had no counterparts in the EM survey were deselected. These “fused data” analyses were then used to create a final “best target analysis” which was used for comparison with the truth tables.

RESULTS

Registration Targets

The rebar stakes create compact, reasonably intense targets in both the magnetometer and EM survey presentations. They were chosen and analyzed as targets from each of the data sets. Table 2 presents the comparisons between the way pointed positions and the positions resulting from the target analyses of the survey

Table. 2. Comparison of Rebar Positions From Target Fitting and the True Positions.

Magnetometer Survey		EM Survey	
X (m)	Y (m)	X (m)	Y (m)
0.11	0.11	0.08	0.03
0.00	0.08	0.11	0.04
0.00	0.08	0.11	0.02
0.05	0.06	0.02	0.01
0.03	0.05	0.09	0.34
0.01	0.12	0.06	0.00
0.01	0.05	0.01	0.11
0.00	0.03	0.13	0.02
0.11	0.07	0.11	0.06
0.01	0.03	0.00	0.15
0.03	0.00	0.22	0.22
0.03	0.03	0.13	0.16
0.01	0.05	0.02	0.09
0.07	0.00	0.00	0.08
0.00	0.02	0.05	0.02
0.06	0.12	0.07	0.00
0.01	0.01	0.04	0.11
0.02	0.03	0.02	0.06
0.08	0.02	0.01	0.09
0.02	0.02	0.03	0.22
0.02	0.09	0.04	0.05
0.02	0.05	0.02	0.04
		0.11	0.46
		0.02	0.42
		0.07	0.03
		0.00	0.00
		0.01	0.05
		0.00	0.07
		0.00	0.14
Average Fit Error (m)		Average Fit Error (m)	
0.03	0.05	0.05	0.11

data. These differences provide a good estimate of the overall uncertainty in the *MTADS* ability to accurately locate targets. The results were surprising to us in that the uncertainty in the target positions (particularly those from the magnetometer survey) approaches the uncertainties that we normally ascribe to the GPS positions alone.

Table 3 presents a summary of the magnetometer, EM and gradiometer target analyses carried out by IDA. The target declarations are evaluated based upon three values for the critical location radius, 0.5, 1.0 and 1.5 m. The magnetometry analyses, as described above, have target picks at 7 levels of probability. The highest confidence picks (Prob. = 0) have an ordnance detection probability of 0.6 (with a 2 meter critical radius) with only 49 false alarms. At the other extreme, (Prob. = 6) 81% of the ordnance is identified, but at the expense of misdeclaring 599 non-ordnance items as targets.
In IDA's analysis of the gradiometer survey, the number of ordnance targets correctly identified in the high probability categories is somewhat improved. Considering the trade-offs between correct declarations and number of false alarms, inclusion of probability levels 0, 1, and 2 (or 0-3 in the gradiometer analysis) produces the best overall performance in the IDA magnetometry and gradiometry analyses. At this level, the probability of detection is somewhat better than 70% with false alarms ratios of 3.0-3.5, or about 35-40 false alarms per hectare. Considering the missed ordnance, there was not a consistent pattern of undetected targets. At the P = 2 level, 7 of the deeper bombs were undetected, but so were 6 of the 60 and 81 mm mortars buried less than 1.5 feet deep.

The IDA EM analysis presents a more consistent detection pattern. In this analysis <u>all ordnance</u> targets less than 2 meters deep were correctly declared, (as were 18 targets buried deeper than 2 meters. Of the 9 missed ordnance, 7 were buried deeper than 3 meters. The false alarm ratio (2 meters radius) was 3.1, or 61 false alarms/hectare. If the IDA magnetometry (Prob. = 0-2) and EM analyses are considered together, 65 of 70 ordnance items were correctly declared, which corresponds to a PD of 0.93.

NRL Target Analysis

Table 4 presents a summary of the NRL analyses of the three surveys carried out independently and the results of the "fused data analysis." The results of the independent EM analysis is very similar to that shown in Table 3 from the IDA study. The number of correct declarations is similar, with somewhat lower false alarms 38-41 vs 61-64 per hectare. Again, all targets at less than 2.0 m were correctly declared. The NRL analysis failed to detect the same specific ordnance items that were missed in the IDA analysis.

Table 3. IDA Target Analysis Results for Magnetometer, EM and Gradiometer Surveys

SURVEY TYPE	ASSIGNED PROBABILITY	TOTAL NUMBER OF TARGETS DECLARED	NUMBER OF CORRECTLY IDENTIFIED TARGETS WITHIN CRITICAL LOCATION RADIUS			FALSE ALARMS/ HECTARE
			0.5 m	1.0 m	2.0 m	
MAGNETOMETER	0	91	29	40	41	20/16/15
	0-1	138	30	46	48	34/29/29
	0-2	179	31	48	50	47/42/41
	0-3	202	31	48	50	54/49/48
	0-4	214	31	48	50	58/53/52
	0-5	221	31	48	50	61/55/54
	0-6	656	33	52	57	198/192/191
EM SURVEY		252	52	59	61	64/62/61
GRADIOMETER	0	111	36	42	47	24/22/2
	0-1	140	37	43	48	33/31/2
	0-2	148	37	43	48	35/33/3
	0-3	156	39	46	51	37/35/3
	0-4	164	40	47	52	40/37/3
	0-5	170	40	47	52	41/38/3
	0-6	302	41	49	54	83/81/7
MAGNETOMETER 0-2 PROBABILITY PLUS EM SURVEY			53	62	65	

Table 4. NRL Target Analysis for Individual and Fused Data Sets

SURVEY TYPE	TOTAL NUMBER OF TARGETS DECLARED	NUMBER OF CORRECTLY IDENTIFIED TARGETS WITHIN CRITICAL LOCATION RADIUS			FALSE ALARMS/ HECTARE
		0.5 m	1.0 m	2.0 m	
MAGNETOMETER	183	48	57	63	43/40/38
GRADIOMETER	201	38	52	57	52/48/46
EM	183	54	60	63	41/39/38
FUSED	263	51	60	66	68/66/64

The NRL magnetometry and gradiometry analyses showed similar patterns to the IDA studies, but consistently showed a somewhat higher declaration accuracy (considering the IDA Probability levels, which produced similar false alarm rates). These differences in analysis results represent, in part, the differences in approach to target classification. More importantly, they reflect the subjective nature of target analysis when the process involves an analyst in the loop. Ongoing efforts at NRL include development of more automated target analysis approaches and approaches to allow correlated analysis of data from multiple sensor sets. If high target detection efficiencies can be maintained after automation, it will remove some of the variable results that reflectsubjective decisions made by the analyst in the loop.

The combined magnetometer and EM detection efficiency from the IDA analysis and the "fused analysis" from NRL produced equivalent PD's, 0.93 vs 0.94. The EM sensor provided the better results for ordnance items buried at less than 2 meters, the passive sensor arrays had better detection efficiencies for targets deeper than 2.5 meters. However, even for the shallower targets, the magnetometer arrays provide superior depth and size information that is critical in making ordnance declaration decisions.

There were several target placement decisions made when the Magnetic Test Range was installed ten years ago that affected the results of this demonstration. A few targets of all sizes were buried below their anticipated limits of detection. In addition, pairs or clusters of targets were buried which we anticipated could not be resolved. Detection technology has improved such that all small and intermediate sized targets were detected. The targets missed in this study were some of the buried pairs and the deepest of the large bombs, which remained below the detection limit in this geologically complex and highly cluttered field.

JEFFERSON PROVING GROUND

The NRL demonstration studies at Jefferson Proving Ground were not an integral part of the commercial demonstrations carried out during the AEC-supported program in the summer and fall of 1996. Therefore, we present the results of the NRL studies here.

We surveyed the three Scenarios: "Aerial Gunnery," "Artillery and Mortars," and "Grenades and Submunitions." Our survey results (based upon "fused analysis" of magnetometry and EM surveys) were prepared in the AEC-required format and submitted to PRC Environmental Management, Inc. for grading using the software package used to evaluate the commercial vendors following round three demonstrations in 1996. Table 5 presents the information relating to survey dates and actual survey times on each of the scenarios. Table 6 summarizes the target results reported. All targets identified were declared either as ordnance or non-ordnance. We did not report ordnance size, but identified the most likely ordnance type (*i.e*. 81 mm mortar, Mk 82 bomb, *etc.*) based upon the DAS fitting routine. Several large targets on the Grenades and Submunitions site were declared as either unknowns or bombs.

Table 7 summarizes the grading information provided to us by the Naval Explosive Ordnance Detection Technology Division. We summarize here only the 1 and 2 meter critical radius values. Within a 1 meter critical radius, our detection efficiency ranged between 93 and 95%. A few additional items were picked up in the 2 meter radius, raising the detection probability to 96-100%. Our false alarms were 139, 147 and 137 on the Aerial Gunnery, Artillery/Mortar and Grenades/ Submunitions sites. Among the few ordnance items that we failed to detect, there was not a consistent pattern of misses, based upon either depth or on size.

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Table 5. NRL Survey Dates and Survey Times for the JPG Scenarios.

Scenario	Survey Dates Mag	Survey Dates EM	Survey Time Mag (Hours)	Survey Time EM (Hours)
Aerial Gunnery	15-16 Jan	22 Jan	5.3	5.8
Artillery & Mortar	16-17 Jan	17-18 Jan	5.4	7.8
Grenades & Submunitions	21 Jan	18-19 Jan	5.9	7.8

Table 6. NRL Target Declarations at JPG

Scenario	Declared Ordnance	Declared Non-Ordnance
Aerial Gunnery	186	81
Artillery & Mortar	218	44
Grenades & Submunitions	213	7 Unknown & Bombs

Table 7. NRL Scoring at JPG Reported by NEODTD

Range/Critical Detection Distance	Ordnance			Non-Ordnance		False Alarms	
	Targets Emplaced	Targets Detected	P.D.	Items Emplaced	Items Detected	False Positives	False Negatives
Aerial Gunnery <1 meter	47	44	0.94	76	64	63	76
Aerial Gunnery <2 meter	47	47	1.00	76	64	64	73
Artillery/Mortars <1 meter	74	70	0.95	49	45	47	100
Artillery/Mortars <2 meter	74	71	0.96	49	46	49	97
Grenades/Submunitions <1 meter	86	80	0.93	38	24	55	82
Grenades/Submunitions <2 meter	86	84	0.98	38	26	60	73